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APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE: RECEIVERLESS AIR  
CONDITIONING SYSTEM

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## RECEIVERLESS AIR CONDITIONING SYSTEM

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5       The present invention relates to an air conditioning system, such as that used with a moving vehicle, that requires storage of excessive refrigerant

#### Discussion of Related Art

10       It is well-known in the art that Thermal Expansion Valve (TXV) and Clutch Cycle Thermal Expansion Valve (CCTXV) air conditioning systems use a receiver to hold excessive refrigerant during low load conditions, such as cool days. Such receivers can have a variety of structures. For example, it is known to use receivers unattached to a condenser of an air conditioning system such as disclosed in U.S. Patent No. 5,172,758. It is also known to attach a receiver to a condenser of an air conditioning system such as  
15       disclosed in U.S. Patents Nos. 4,972,683; 5,088,294; 5,172,758; and 5,546,761, the entire contents of each of which are incorporated herein by reference. Whether the receiver is unattached or attached with the condenser, the air conditioning system is bulkier and more costly to produce. A disadvantage of air conditioning systems that require subcooled refrigerant  
20       and have attached receivers is that the subcool temperature is not allowed to change with changing load conditions. A disadvantage of air conditioning systems that require subcooled refrigerant but do not have attached receivers

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is that excessive refrigerant is needed to allow the subcool temperature to change with load conditions.

In view of the above-described disadvantages, it is an object of the present invention to provide an air conditioning system that is less bulky and less costly to manufacture.

Another object of the present invention is to provide an improved air conditioning system that requires a subcooled refrigerant where the subcool temperature is allowed to change with the load without requiring excess refrigerant charge in the air conditioning system.

## 10 SUMMARY OF THE INVENTION

One aspect of the present invention regards a condenser that includes a top manifold defining a first volume of space and a bottom manifold positioned below the top manifold and defining a second volume of space that has a magnitude that is different than the magnitude of the first volume of space. A core positioned between the top manifold and the bottom manifold, the core including a first set of condenser tubes that are in fluid communication with the top manifold and a second set of condenser tubes that are in fluid communication with the bottom manifold.

A second aspect of the present invention regards an air conditioning system including a moving vehicle that has an engine, a radiator positioned so as to cool the engine and a condenser mounted to the moving vehicle so as to be positioned in front of the radiator. The condenser includes a top manifold defining a first volume of space and a bottom manifold positioned below the

top manifold and defining a second volume of space that has a magnitude that is different than the magnitude of the first volume of space. A core positioned between the top manifold and the bottom manifold, the core including a first set of condenser tubes that are in fluid communication with  
5 the top manifold and a second set of condenser tubes that are in fluid communication with the bottom manifold.

A third aspect of the present invention regards a condenser that includes a first manifold defining a first volume of space and a second manifold defining a second volume of space that has a magnitude that is  
10 substantially the same as the magnitude of said first volume of space. A core is positioned between the first manifold and the second manifold, the core including a first set and a second set of condenser tubes that are each in fluid communication with the first manifold and the second manifold, wherein a refrigerant is present in a gas phase and liquid phase within the first and  
15 second set of condenser tubes, the liquid phase is contained exclusively within the first and second set of condenser tubes irrespective of the thermodynamic conditions within the condenser.

A fourth aspect of the present invention regards an air conditioning system that includes a moving vehicle that has an engine, a radiator  
20 positioned so as to cool the engine and a condenser mounted to the moving vehicle so as to be positioned in front of the radiator. The condenser includes a first manifold defining a first volume of space and a second manifold defining a second volume of space that has a magnitude that is substantially

the same as the magnitude of said first volume of space. A core is positioned between the first manifold and the second manifold, the core including a first set and a second set of condenser tubes that are each in fluid communication with the first manifold and the second manifold, wherein a refrigerant is  
5 present in a gas phase and liquid phase within the first and second set of condenser tubes, the liquid phase is contained exclusively within the first and second set of condenser tubes irrespective of the thermodynamic conditions within the condenser.

Each of the above aspects of the present invention provides the  
10 advantage of decreasing the bulk and cost of an air conditioning system.

Each of the final two aspects of the present invention provides the advantage of allowing the subcool temperature to change with the load without requiring excess refrigerant charge in air conditioning systems that require subcooled refrigerant.

15 The present invention, together with attendant objects and advantages, will be best understood with reference to the detailed description below in connection with the attached drawings.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 schematically shows an air conditioning system according to the  
20 present invention;

FIG. 2 shows a front cross-sectional view of an embodiment of a condenser according to the present invention to be used with the air conditioning system of FIG. 1;

FIG. 3 shows a front cross-sectional view of a second embodiment of a condenser that could be used with the air conditioning system of FIG. 1;

FIG. 4 shows a front cross-sectional view of a third embodiment of a condenser that could be used with the air conditioning system of FIG. 1;

5 FIG. 5 shows a front cross-sectional view of a fourth embodiment of a condenser that could be used with the air conditioning system of FIG. 1; and

FIG. 6 schematically shows a perspective view of a vehicle employing the air conditioning systems and condensers of FIGS. 1-5 according to the present invention.

## 10 DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, FIG. 1 shows an embodiment of an air conditioning system 10 to be used with a vehicle, such as a car 12 or truck. It is understood that the air conditioning system 10 can be used with other types of vehicles or other enclosed areas that need to be cooled.

15 As shown in FIG. 1, the air conditioning system 10 includes a refrigerant compressor 14, a refrigerant condenser 16, a sight glass 18, an expansion valve 20 and a refrigerant evaporator 22, all of which are serially connected by a metal or rubber refrigerant pipe 24. The refrigerant compressor 14 is connected to an engine 26 of the vehicle through a belt 28  
20 and an electromagnetic clutch 30. Note that the sight glass 18 and the electromagnetic clutch 30 are optional.

When the engine 26 and the air conditioning system 10 are turned on, the belt 28 via clutch 30 power the refrigerant compressor 14 resulting in the

refrigerant compressor sucking in the refrigerant in the gas phase from the refrigerant evaporator 22. The refrigerant compressor 14 then compresses the sucked in refrigerant and discharges a high temperature and high-pressure gas refrigerant to the refrigerant condenser 16.

5           The refrigerant condenser 16 is mounted to a body of the vehicle so as to be positioned in normally at the front side of a radiator for cooling the engine cooling water so that it can easily receive the wind during the running of the vehicle. As shown in FIG. 2, the refrigerant condenser 16 is made in a downflow arrangement with two passes. The refrigerant condenser 16  
10 includes a top manifold 32 that is made of the same material as the tubes 52, 56 discussed below and is cylindrical in shape having a diameter that is approximately 4mm greater than the diameters of the tubes 52 and 56. The top manifold 32 includes an inlet 34 that receives the high temperature and high-pressure gas refrigerant from the refrigerant compressor 14. The top  
15 manifold 32 is divided via a partition 36 into a chamber 38 that is in fluid communication with the inlet 34 and an exit chamber 40 that is in fluid communication with an outlet 42. The partition 36 is positioned so that the second pass is approximately 10% of the first pass.

          The high temperature and high pressure gas refrigerant within the  
20 upper chamber 38 is fed to a core 44 that acts as a heat exchanger. As shown in FIG. 2, the core 44 includes a condensing section 46 and a condensing and super cooling section 48. The condensing section 46 is in fluid communication with the chamber 38 of the top manifold 32 and a bottom

manifold 50 via a plurality of vertically extending condensing tubes 52. A plurality of corrugated fins 54 are positioned between and joined to the condensing tubes 52 by brazing or other joining method.

The condensing section 46 condenses the gas refrigerant flowing therein by heat exchanging the gas refrigerant with the fresh air delivered by a cooling fan (not illustrated) and other devices. The condensed gas refrigerant is received in the bottom manifold 50 that is made of the same material as the tubes 52, 56 and is cylindrical in shape having a diameter that is approximately 8mm greater than that of the tubes 52, 56. While the bottom manifold 50 has the same length as the top manifold 32, the bottom manifold 50 has a larger diameter than that of the top manifold 32 to accommodate excessive refrigerant during low load conditions. Note that a desiccant preferably is incorporated within the interior of the bottom manifold 50 to remove water from the refrigerant present therein.

A variation of a condenser that can replace the condenser 16 described previously is shown in FIG. 3. In particular, the condenser 16' is the same as the condenser shown in FIG. 2 except that the inlet 34 has been repositioned, the outlet 42 has been moved to the top manifold 32 and the bottom manifold 50' has been reduced in size so as to be identical in size with the top manifold 32. The reduction in size is possible because it is possible to store excess liquid refrigerant within the confines of the tubes 52, 56 alone without resorting to expanding the size of the bottom manifold as is done in the embodiment of FIG. 2. This concept is shown in FIG. 3. In particular, the



condenser 16' can be thought of having a refrigerant distribution defined by three zones: a) zone I contains refrigerant in a mostly high-pressure gas phase, b) zone II contains refrigerant that is a mixture of gas and liquid phases, and c) zone III contains refrigerant in a mostly liquid phase. FIG. 3 shows a typical refrigerant distribution in a high load situation where the air conditioning system has been turned on. As can be seen, zone I is primarily located near the inlet 34 and takes up a small percentage of the condenser 16'. Zone II is adjacent to zone I and takes up a large percentage, such as approximately 70%, of the remaining area of the condenser 16'. Zone III is adjacent to zone II and the outlet 42. Zone III takes up a percentage of approximately 25%.

During normal air conditioning operation the amount of refrigerant in the liquid phase fluctuates. The amount of liquid refrigerant in the condensing tubes 52 and the condensing and supercooling tubes 56 causes the system operating pressure to continually adjust and provide the most efficient operation. If there is an abundance of liquid refrigerant in tubes 56 the excess will back into tubes 52. So, in the case of FIG. 3, should the load on the air conditioning system increase, then condensing zones I and II increase in size while zone III decreases in size. Such an increase in size aids in reducing the high operating pressure. Should the load decrease, then zones I and II decreases in size while zone III increases in size. Thus, the sizes of the zones continually change depending on the load and operating pressure of the system. What does not change is that the liquid refrigerant is contained

within the condenser 16' without the need of an enlarged bottom manifold or a receiver. By storing the liquid refrigerant in the heat exchange area of the system (rather than a receiver that does not exchange heat), a minimal amount of refrigerant charge is required to provide the maximum benefit  
5 under all load conditions.

While the condenser 16' of FIG. 3 is of the downflow type, the principles of condenser 16' can be applied to crossflow type condensers as well. Such a condenser 16'' is shown in FIG. 4. In this embodiment, the top and bottom manifolds 32, 50 of FIG. 3 are replaced by left and right side  
10 manifolds 32'', 50'', respectively, that are reduced in length and the tubes 52 and 56 are oriented horizontally and lengthened. Again, three zones are formed where the size of the zones varies depending on the load condition in the manner described above.

A variation of a condenser that can replace the condenser 16  
15 described previously is shown in FIG. 5. In particular, the condenser 16''' is the same as the condenser shown in FIG. 2 except that the inlet 34 has been moved and the bottom manifold 50' includes a depression 51. Such a depression 51 is described in U.S. Patent Application Serial No. 09/753,298, filed on December 29, 2000, the entire contents of which are incorporated  
20 herein by reference.

In each of the condensers 16, 16', 16'' and 16''' described previously with respect to FIGS. 2-5, the condensed gas refrigerant received by the manifolds 50, 50', 50''' reenters the supercooling section 48 of the core 44

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that is located adjacent the condensing section 46. The supercooling section 48 includes a plurality of vertically (FIGS. 2-3 and 5) or horizontally (FIG. 4) extending supercooling tubes 56 and a plurality of corrugated fins 58 joined to the tubes 56 by brazing or other joining method. The condensed gas

5 refrigerant passes through the supercooling tubes 56 and passes out of the refrigerant condenser 16, 16', 16'', 16''' via the outlet 42. The supercooling section 48 supercools the liquid refrigerant flowed therein by exchanging the heat of the liquid refrigerant with the fresh air delivered by the cooling fan and other devices.

10 Note that the plurality of condensing tubes 52 and supercooling tubes 56 are each made in a well known manner, such as extruding an aluminum or aluminum alloy material having a high corrosion resistance and a high heat conductivity into a desired cross-sectional shape, such as a circle with a diameter of 8 to 22mm. One difference between the condensing tubes 52 and  
15 the supercooling tubes 56 is that the supercooling tubes 56 are longer in length to reach any liquid refrigerant residing in the lowest portion of the bottom manifold 50, 50'. In addition, the number of the condensing tubes 52 is larger than the number of the supercooling tubes 56 such that the number of the supercooling tubes 56 is about 10% of the total number of tubes within  
20 the core 44. The corrugated fins 54 and 58 are also made in a well-known manner, such as press working aluminum or aluminum alloy plates into a corrugated shape.

The refrigerant condenser 16, 16', 16'', 16''' expels the supercooled

refrigerant via outlet 42 so that it flows through the sight glass 18 and to the expansion valve 20. Note that in the case of the condensers 16' and 16'', the air conditioning system is charged such that the refrigerant condenser expels supercooled refrigerant under all conditions, additional refrigerant charge is added for leak protection. The expansion valve 20 functions as a pressure reducing device for turning the high pressure, high temperature refrigerant flowed therein from the sight glass 18 to the low temperature, low pressure atomized refrigerant into gas and liquid by adiabatically expanding the refrigerant.

The low temperature, low pressure refrigerant is received in the refrigerant evaporator 22 that heat exchanges the low temperature, low pressure refrigerant with fresh air or recirculated air blown in by a blower (not shown) from the interior space to be cooled, such as the interior 32 of the vehicle, which causes the refrigerant to evaporate. The latent heat of vaporization that results from the heat exchanging and evaporation cools blowing air that is passed through the refrigerant evaporator 22. The cooled air is then fed to the interior 32 of the vehicle.

Now, the operation mode of the refrigerating cycle will hereinafter be described. When the automotive air conditioner begins operation, the refrigerant compressor 14 is driven to rotate by the engine 26 through the belt 28 and the electrically energized electromagnetic clutch 30. Then, the high temperature, high-pressure gas refrigerant compressed in the refrigerant compressor 14 is discharged therefrom and flows into the inlet 34 of the

manifold 32 of the refrigerant condenser 16, 16', 16'', 16'''. The gas refrigerant then is distributed into the plurality of condensing tubes 52 where it is concurrently heat exchanged with the fresh air through the corrugated fins 54 to be condensed and liquefied. Most of the gas refrigerant is liquefied in this process while the rest remains in the gas phase. The liquid and gas phases of the refrigerant flow from the condensing tubes 52 into the manifold 50, 50'. The refrigerant flows into the supercooling tubes 56 where further heat exchanging with the fresh air takes place. The liquid refrigerant then exits from the supercooling tubes 36, and exits out of the outlet 42 and flows to the sight glass 18 and the process repeats itself. Note that the condenser 16 is located in front of the radiator of the car 12 of FIG. 4.

The foregoing description is provided to illustrate the invention, and is not to be construed as a limitation. Numerous additions, substitutions and other changes can be made to the invention without departing from its scope as set forth in the appended claims. For example, the present invention may also be applied to any air-conditioner for rail cars, ship or airplanes, for example, in which the variation in the circulating refrigerant quantity is large.